Calibration and Analysis of Global Latent Heating Estimates Using Passive and Active Microwave Sensor Data

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Abstract

The release of latent heat into the atmosphere by precipitation processes is a critical transformation that links the earth's hydrologic and energy cycles. Preferential solar heating of the tropical oceans leads to higher sea surface temperatures and enhanced fluxes of moisture into the atmosphere- over three quarters of this moisture condenses in convective cloud systems, and the latent heat released in these clouds thus represents the movement of the sun's energy into the atmosphere (Simpson, 1992). Latent heating plays a major role in the forcing of circulations over a range of scales in the tropics, from mesoscale convective systems to the Hadley and Walker circulations. Pronounced interannual variations of large-scale precipitation/latent heating distributions are associated with the El Nino-Southern Oscillation (ENSO) cycle, which has a dominant impact in the tropics but is also linked to weather-related changes in the extra-tropics (see Adler et al. 2000, Hoerling et al. 2001). In addition, preliminary studies of the assimilation of latent heating distributions into numerical weather prediction model forecasts have shown promising results (e.g.Wang and Warner 1988; Puri and Miller 1990; Raymond et al. 1995).

Clearly a knowledge of global latent heating distributions would be valuable not only from the standpoint of understanding the earth's water and energy cycles, but also for climate and numerical weather prediction applications. Nevertheless, only limited progress has been made in estimating latent heating from sensors that have the frequency of sampling to derive reliable global distributions. Latent heating estimation from passive microwave radiometry has shown promise, as microwave radiance data are sensitive to precipitation and latent heating distributions, and several satellite-borne microwave radiometers are now operational. However, methods for estimating latent heating from microwave radiometry are sensitive to the calibration data, currently provided by cloud-radiative model simulations, that establish the relationships between observed radiances and precipitation/heating vertical profiles. Systematic differences between modeled and naturally-occurring precipitation/latent heating profiles lead to biased calibration data and errors in radiometer-inferred heating.

We propose to calibrate a method for deriving latent heating distributions over global oceanic regions from passive microwave radiometer observations from multiple satellite platforms using an extended time series of high-resolution, combined radar-radiometer estimates of precipitation/latent heating vertical structure. The combined radar-radiometer method developed by the investigators (Grecu et al. 2004) will be used to derive precipitation vertical profiles from Tropical Rainfall Measuring Mission (TRMM) precipitation radar (PR) and TRMM Microwave Imager (TMI) data. Latent heating will be assigned to the high-resolution precipitation profiles using a method similar to that of Shige et al. (2004). The extensive sampling of precipitation systems in the tropics/subtropics by the PR-TMI will lead to a calibration dataset that is fairly general and relatively unbiased. The radiometer method will first be developed for TMI and then extended to other satellite microwave radiometers, including the Advanced Microwave Scanning Radiometer-EOS (AMSR-E) and Special Sensor Microwave/Imager (SSM/I). Radiometer latent heating estimates will be evaluated against independent PR-TMI heating data as well as rawinsonde network analyses of heating. Experimental multi-satellite latent heating products, including an instantaneous, 0.5^{o} resolution product suitable for data assimilation and a monthly, 2.5^{o} resolution product for climate analysis will be derived and examined.